Request for Economic Stimulus Funds

Concept Proposal

Submitters (Name of Workgroup & Chair/Co-Chairs):

Murray State University, Evolvable Systems Laboratory, Dr. James Hereford (chair)

Project Title:

Swarm systems for robotic exploration

Project Partners (Known or Anticipated):

Murray State University, Mid-America Remote Sensing Center

Concurrent Solutions, LLC, Murray, KY

University of Kentucky, Intelligent Dependable Embedded Architectures (IDEA) Laboratory

Project Background & Purpose (Justification for Project):

What we propose is to leverage off of current technology and develop a swarm robotic system that:

(i) utilizes a suite of small, mobile robots instead of one large, expensive robot;
(ii) can autonomously explore and map in a cluttered, rough and/or remote environment, such as another planet;
(iii) is easily adaptable to search for different objects;
(iv) makes use of new, distributed search algorithms that make the overall system robust and tolerant of failures in individual robot agents;
(v) can be reconfigured to perform other operations.

Our goal is to build a swarm of (very) small robots that can search over possibly rough terrain for an object or objects and then reconfigure themselves to do another operation or task. We envision that the robots will be about the size of a quarter dollar, or smaller, and have a sensor or

sensors that "sniff" out the desired target. This type of scenario has many possible applications. The bots will be able to maneuver to track a plume or target signature (e.g., a beacon) and then cluster at the target location.

But the bot swarm will not only be able to autonomously search and explore. The swarm can be reconfigured to perform other applications such as gathering information about the terrain, form an antenna array, work together to move objects, bond together to transverse crevices and rough terrain. All of these actions (antenna array, move objects, bond together) have been demonstrated using robot swarms. This research would merely use the existing ideas and consolidate them into one swarm system. The result will be a system that is cheap relative to using large robots, versatile, reconfigurable, fault tolerant, scalable to large numbers, and re-usable.

Project Description (General Goals & Implementation Strategies):

We will use a swarm of small, autonomous robots to perform the exploration operation. The robots will communicate with each other and to an interface unit that can be (remotely) monitored by a human operator. The human operator will be able to issue top-level commands ("explore", "continue", "come home") but will not be able to control the individual robots.

We will break the robot swarm system into three primary subsystems that will be developed. System 1 is the user interface that will combine Geographic Information Systems (GIS) principles with robot communications to provide the operator with current information about the robot swarm. System 2 will be the robot hardware design: size, sensors, mobility, communications, power, gripper characteristics. System 3 will be the distributed algorithms that will be used by the individual robots to complete the assigned task.

Each robot in the swarm of robots has the following characteristics. It is small, both in size and in weight, so the processor must be small and have limited computational capability. The robot is self-contained in terms of power. It is mobile, though it may be limited in terms of steering radius and speed. It has a sensor or an array of sensors that can make measurements.

Most of the algorithms that will be needed have already been developed. The algorithms that we have already developed include dispersing the bots, searching with the swarm, and gathering information. The algorithms were designed to be distributed, scalable and with minimal bot-bot communications to fit the robot swarm.

Thus, each of the three subsystems will be based on current technology and, in most cases, commercially-available technology. This reduces development and testing time and expense. The final product will be able to disperse the bots over a wide area, gather information, congregate back together and then form an antenna array pattern for communication.

Project Team (Project Manager(s), Content Experts, Instructional Designers, etc.):

Dr. James Hereford (PI) – Algorithm development

Dr. Haluk Cetin – Geographic Information Systems, system integration

Dr. Bob Pilgrim – Robot hardware development

Dr. Jim Lumpp – Manufacturing, testing

Plus, students and technicians to support the content experts.

Project Budget & Amount of Economic Stimulus Funds Requested:

	Year 1	Year 2
Faculty salary support:	$ 55,000	$ 50,000
Summer support for 3 faculty		
Undergraduate and graduate student support:	$ 60,000	$ 60,000
2 graduate students + 2 undergraduate students		
Research engineer:	$ 65,000	$ 67,000
A BS engineer or physicist to coordinate assembly and test of swarm		
Robot development and build (includes supplies):	$ 70,000	$ 40,000
Laboratory equipment + travel:	$ 30,000	$ 8,000
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Total	$280,000	$225,000

Total funds requested = $505,000